TECHNICAL MANUAL

PORTABLE ION CHAMBER

MODEL RO-1

EBERLINE
Instrument Corporation
SANTA FE NEW MEXICO

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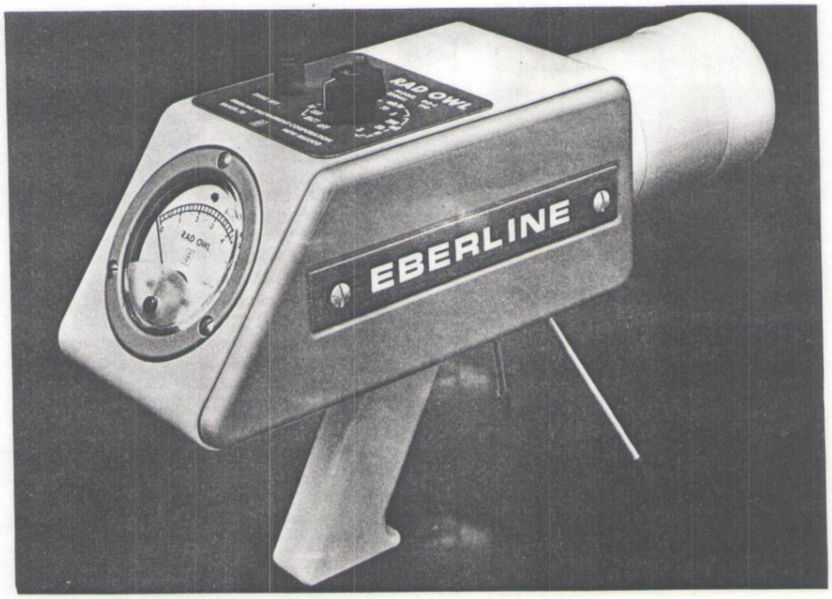


Figure 1-1. RAD OWL, Model RO-1

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The RAD OWL, Model RO-1, is a portable air ion chamber instrument used to measure beta, gamma, and x-ray radiation. The RAD OWL has nine linear ranges of operation, six to measure dose rate and three integrating ranges to measure total dose received. The ion chamber is vented to atmospheric pressure and is specifically designed to have flat energy response into the x-ray region. The Model RO-1 is sensitive to alpha, beta, gamma and x-ray and is calibrated to gamma radiation. A single rotary switch turns the instrument off, provides a battery check and selects the range and mode of operation. Separate zero controls permit checking of the zero setting while in a radiation field.

B. SPECIFICATIONS

1. DETECTOR

a. Size: 3-inch diameter, volume 250 cc (15.25 cubic inches).

b. Fill: Air, vented to atmospheric pressure.

c. Wall: One-sixteenth inch phenolic, approximately 200 mgm/cm^2.

d. Window: Two layers .00025 inch mylar, approximately 1.7 mgm/cm^2.

e. Radiation Detected: Alpha, beta, gamma, x-ray.

f. Photon Energy Response: Nominal ±15% from 6.5KEV to 1.2MEV. (See Figure 1-2.)

g. Examples of Beta Response

(1) Uranium Slab: 30% of true mRAD/hr field behind 7 mgm/cm^2 window with RAD OWL chamber in contact with slab, cap off.

(2) ^{90}Sr - ^{90}Y: 75% of true mRAD/hr field at 20 cm with cap off, 28% with cap on, 23% through chamber side.

(3) ^{99}Tc Thin Slab: 30% of true mRAD/hr field behind 7 mgm/cm^2 window with RAD OWL chamber in contact with slab, cap off.

h. Fast Neutron Response: Reads approximately 10% in mR/hr of true neutron field in mREM/hr.

2. GENERAL

a. Ranges

(1) Dose Rate: Six linear ranges. 0-5, 0-50, 0-500 mR/hr, 0-5, 0-50, 0-500 R/hr.

(2) Integrate: Three linear ranges. 0-5, 0-50, 0-500 mR.

b. Maximum Dose Rate During Integration: 1000 R/hr (10,000 R/hr using correction curve).

c. Meter: Ruggedized, sealed, 2.38 inch scale length, 2% accuracy MIL-SPEC type. Linear markings from 0 to 5 in 25 minor increments.

d. Response Time: 7 seconds on 5 mR/hr range. Other ranges 4 seconds. (0 to 90% of final reading.)

e. Linearity: Within ±5% of full scale.

f. Battery Dependence: No calibration shift with battery voltage change (down to BATT check mark on meter).

g. Controls

(1) External: Range switch with OFF and BATT check positions. Engraved switch markings. ZERO pushbutton to start integration period or check instrument zero when in radiation field. ZERO SET knob used to set meter to zero when ZERO pushbutton is depressed.

(2) Internal: Nine calibration controls, one for each range. Two controls on printed circuit board to set amplifier current (set at factory).

h. Batteries

(1) Type: Two "D" size cells, 1.0 to 1.7 volts per cell.

(2) Life: Approximately 80 hours carbon-zinc, 130 hours alkaline, 290 hours mercury.

i. Environment

(1) Temperature: Operable from 0°C to 60°C (32° to 140°F).

(2) Moisture: Seals used at all openings for dust

and water resistance. Detector is protected by a silica-gel drying box.

j. Weight: 5-1/2 lbs. (2.5 kgm) maximum, including carbon-zinc batteries.

k. Size: 4-3/4" W x 13-1/2" L x 9" H, including handle.

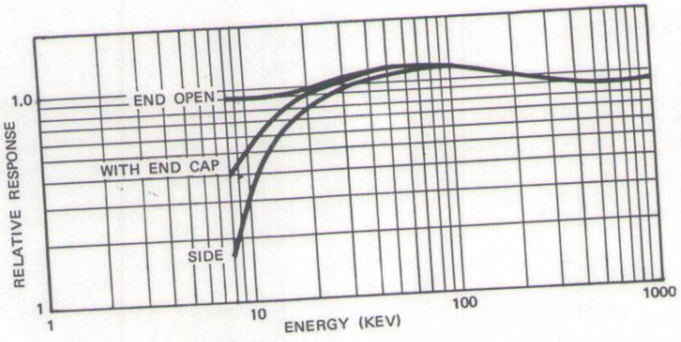


Figure 1-2. Nominal Photon Energy Response

SECTION II

OPERATION

A. DESCRIPTION OF CONTROLS

1. EXTERNAL

a. Function switch: Eleven position rotary switch that turns the instrument OFF, checks the BATTery condition and selects the range and mode of operation to be used.

b. ZERO pushbutton: Used to bring the meter reading to zero to start an integration period or to check instrument zero when in a radiation field.

c. ZERO SET knob: Used to set the meter to zero when ZERO pushbutton is depressed.

2. INTERNAL

a. Calibration controls: Nine variable resistors, one for each range.

b. Amplifier Current controls: Two variable resistors on plug-in printed circuit board, factory set for proper amplifier current.

B. USING THE INSTRUMENT

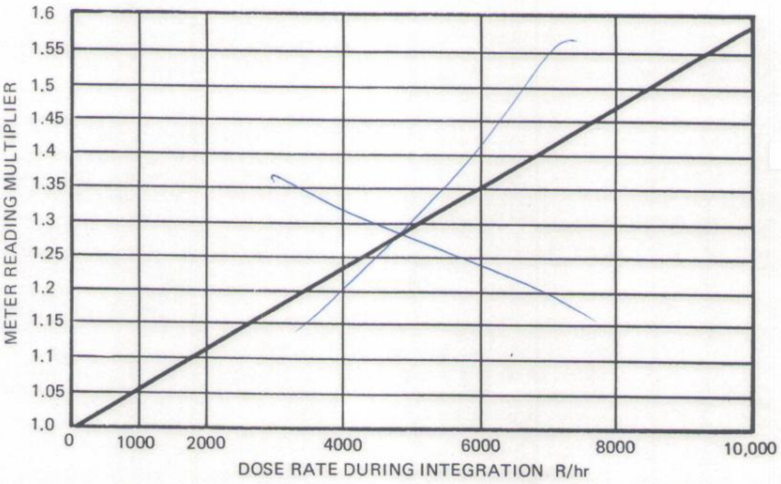
1. Turn the function switch to BATT position. The meter should read above the BATT cut-off line.

2. Turn the function switch to 500 R/hr position. Check that the meter reads zero (assuming the absence of a high radiation field).

3. Set the function switch to the desired range of operation. The switch position selected is the full scale reading of that range.

4. If one of the six dose rate ranges (R/hr or mR/hr) was selected, read the dose rate directly on the meter by keeping in mind what the full scale reading represents.

5. If one of the three integrating ranges (mR-INT) was selected, momentarily depress the ZERO pushbutton to start the integration period. At the end of the period, read the total dose received directly on the meter by keeping in mind what the full scale reading represents. If the dose rate during integration was over 1000 R/hr, refer to Figure 2-1 for a correction factor.



Ro-3C
does
NOT
INTEgrate

Figure 2-1. High Dose Rate Correction Curve

		TEMPERATURE WHEN CALIBRATED (°F)											
		30	40	50	60	70	80	90	100	110	120	130	140
TEMPERATURE WHEN USED (°F)	30	1	.98	.96	.94	.92	.91	.89	.87	.86	.84	.83	.82
	40	1.02	1	.98	.96	.94	.93	.91	.89	.88	.86	.85	.83
	50	1.04	1.02	1	.98	.96	.94	.93	.91	.89	.88	.86	.85
	60	1.06	1.04	1.02	1	.98	.96	.95	.93	.91	.90	.88	.87
	70	1.08	1.06	1.04	1.02	1	.98	.96	.95	.93	.91	.90	.88
	80	1.10	1.08	1.06	1.04	1.02	1	.98	.96	.95	.93	.92	.90
	90	1.12	1.10	1.08	1.06	1.04	1.02	1	.98	.96	.95	.93	.92
	100	1.14	1.12	1.10	1.08	1.06	1.04	1.02	1	.98	.97	.95	.93
	110	1.16	1.14	1.12	1.10	1.08	1.06	1.04	1.02	1	.98	.97	.95
	120	1.18	1.16	1.14	1.12	1.09	1.07	1.05	1.04	1.02	1	.98	.97
	130	1.20	1.18	1.16	1.13	1.11	1.09	1.07	1.05	1.04	1.02	1	.98
	140	1.22	1.20	1.18	1.15	1.13	1.11	1.09	1.07	1.05	1.03	1.02	1

MULTIPLY METER READING BY GIVEN CORRECTION FACTOR

Table 2-1. Temperature Corrections

NOTES

a. The zero setting of the instrument may be checked at any time on any range and in any radiation field by merely depressing the ZERO pushbutton. Since any zero offset will be most noticeable on the "5" ranges (5 R/hr, 5 mR/hr, 5 mR), adjusting the meter reading to zero with the ZERO SET knob should be done only on one of these three ranges. Once set, no adjustment should again be necessary when using the "500" or "50" ranges. Small re-adjustments may be necessary on the "5" ranges.

b. Depressing the ZERO pushbutton will erase the integrated reading when on one of the three integration ranges. To check for possible zero offset without losing the reading, switch to the 5 mR/hr (or 5 R/hr) position, depress the ZERO pushbutton and set to zero using the ZERO SET knob. Release the ZERO pushbutton. Return to the integrate position and read the meter or continue integrating, if desired.

c. The dose rate may be checked at any time during an integration period by merely switching to the desired range, reading the dose rate and then returning to the integrate range to continue integrating.

d. When selecting the most sensitive range, (5 mR/hr) switching transient noise, including releasing the ZERO pushbutton, may cause a temporary offscale reading on the meter. This can be avoided by first selecting 500 mR/hr, letting the needle settle, then repeating at 50 mR/hr, and then switching to 5 mR/hr.

e. The effective center of the ion chamber is marked by a groove around the outside about 1-3/4" from the front end.

f. Since the ion chamber is vented to atmospheric pressure, it is sensitive to changes in both air pressure and temperature. Tables 2-1 and 2-2 give correction factors to be used if the use conditions are different from the calibration conditions. If both pressure and temperature are different, multiply the meter reading by both factors.

CAUTION

When using the RO-1 on the integrate (INT-mR) ranges, do not continue the integration after the meter reaches full scale. To do so can cause a large zero offset with a very slow recovery. If more than a total continuous dose of 2R is received, permanent damage may result.

Ro3C
dosen't
integrate

		ALTITUDE WHEN CALIBRATED										
		SEA LEVEL	1000’	2000’	3000’	4000’	5000’	6000’	7000’	8000’	9000’	10,000’
ALTITUDE WHEN USED	SEA LEVEL	1	.96	.93	.90	.86	.83	.80	.77	.74	.71	.69
	1000’	1.04	1	.96	.93	.90	.86	.83	.80	.77	.74	.71
	2000’	1.08	1.04	1	.96	.93	.89	.86	.83	.80	.77	.74
	3000’	1.12	1.08	1.04	1	.96	.93	.89	.86	.83	.80	.77
	4000’	1.16	1.12	1.08	1.04	1	.96	.93	.89	.86	.83	.80
	5000’	1.20	1.16	1.12	1.08	1.04	1	.96	.93	.89	.86	.83
	6000’	1.25	1.20	1.16	1.12	1.08	1.04	1	.96	.93	.89	.86
	7000’	1.30	1.25	1.20	1.16	1.12	1.08	1.04	1	.96	.93	.89
	8000’	1.35	1.30	1.25	1.21	1.16	1.12	1.08	1.04	1	.96	.93
	9000’	1.40	1.35	1.30	1.25	1.21	1.16	1.12	1.08	1.04	1	.96
	10000’	1.45	1.40	1.35	1.30	1.26	1.21	1.17	1.12	1.08	1.04	1

MULTIPLY METER READING BY GIVEN CORRECTION FACTOR

Table 2-2. Altitude Corrections

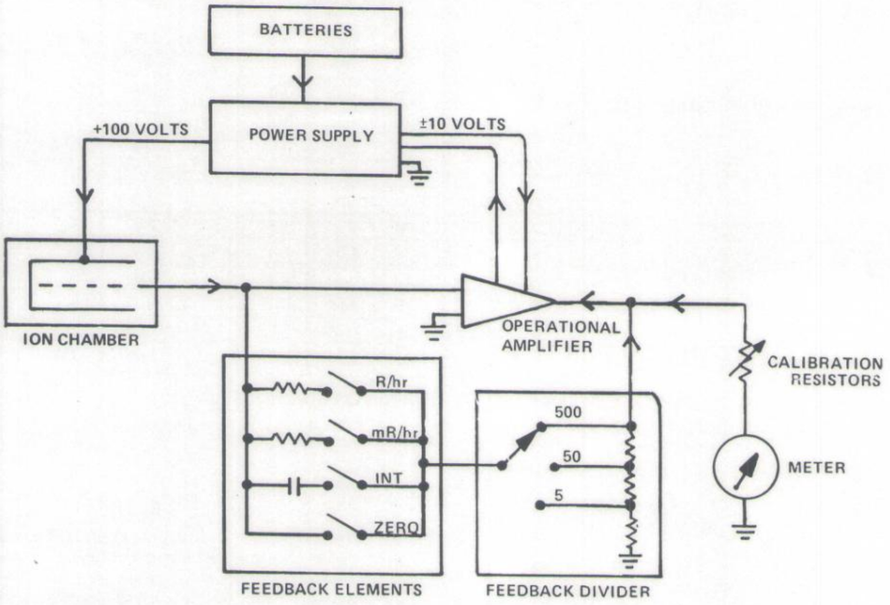


Figure 3-1. System Block Diagram

SECTION III

THEORY OF OPERATION

A. GENERAL

Refer to Figure 3-1, a block diagram representing the basic operation of the circuit. The ion chamber has a potential of 100 volts between the inside wall and the center electrode. When the air in the chamber ionizes due to radiation, a minute current flows through the chamber causing the minus input lead of the operational amplifier to go very slightly positive. This results in a negative swing of the amplifier output which is connected to the feedback elements through a divider circuit. The feedback elements are connected to the amplifier input and the ion chamber and they conduct away all of the current generated in the ion chamber. The meter is also tied to the output of the amplifier and indicates in proportion to amplifier output voltage. Range changing is done by selecting different feedback elements and by selecting different points on the feedback divider.

B. FUNCTIONAL THEORY

1. ION CHAMBER

The ion chamber consists of the forward three inches (approximately) of the cylindrical assembly at the front of the instrument. The phenolic outer tube is 3" in diameter and has a 1/16" thick wall. The removeable face assembly has two layers of 0.00025 inch thick aluminized mylar equal to 1.7 mgm/cm^2 total density. The mylar is supported by a narrow grid array of 0.005 inch thick aluminum. The center electrode is a phenolic cylinder 1.5 inches in diameter and 1.6 inches long, making the active volume of air in the chamber 250 cc.

The inside of the chamber has a conductive coating of graphite dag which is maintained at +100 volts. The inside mylar face is also at +100 volts. The outside of the chamber is coated with dag (under the beige paint) and is maintained at ground potential to provide electrostatic shielding. The outside mylar face is also at ground potential. The center electrode is coated with conductive dag and is supported on the center conductor of the guarded feedthrough at the rear of the chamber. The guard ring of the guarded feedthrough is positioned on insulators between the center conductor and the +100 volt outer ring to prevent possible leakage from the high voltage to the center electrode. The guard ring and center electrode are maintained at the same potential (ground potential) so no leakage from the guard to the electrode will occur.

The chamber is sealed except for a small hole in the rear wall which vents it to the electronic section immediately behind the chamber. This section is vented to the inside of the main instrument case through a plastic hose connected to a drying box filled with silica gel desiccant. In this way, any air drawn into the chamber (caused by atmospheric pressure changes, temperature changes, transporting the RO-1 by air, etc.) must first pass over the drying desiccant. Dry air in the chamber is necessary to help prevent leakage.

An idealized air chamber the size of the one used on the Model RO-1 produces approximately 2.32×10^{-14} amps per mR/hr at standard temperature and pressure (STP is 0°C and sea level pressure of 760 mm of Hg). At 5 mR/hr it should produce 1.16×10^{-13} amps and at 500 R/hr it should produce 1.16×10^{-8} amps. It is seen that at full scale on the most sensitive ranges (5 mR/hr), only about 1/10 of a micro-microamp is produced in the chamber which makes protection against leakage current paramount. The silica gel desiccant should be changed as soon as it shows any clear or pink crystals.

2. OPERATION AMPLIFIER (See Figure 6-1.)

The amplifier consists of transistors Q7 through Q12 and associated components. It has extremely high input impedance and moderately high voltage gain (nominally 5000). The input element is transistor Q7, a dual, matched MOSFET with an input impedance on the order of 10^{15} ohms. One input gate, pin 5, is tied to ground and the other, pin 3, is at ground potential (within one millivolt) when the amplifier is in balance. Pin 3 is connected to the center electrode of the ion chamber and to the feedback elements R9, R10 and C9. The drains of Q7 are tied to the bases of Q10 and Q11 which are connected as a differential input amplifying pair. The output of Q11 (Q11 collector) feeds the base of Q12 which again amplifies the signal. The output of Q12 feeds one of the feedback elements either directly or through the divider network of R20, R21 and R22.

When ion chamber current flows toward the gate of Q7, the gate becomes slightly more positive. This causes a decrease in drain current at pin 2 and an increase in drain current at pin 6. The voltage across R13 decreases and the voltage on R14 increases which causes Q10 to conduct more and Q11 to conduct less. When Q11 conducts less, the voltage across R19 decreases which causes Q12 to conduct less. This causes the voltage across R23 to decrease and the voltage on the collector of Q12 goes more negative. This negative output of the amplifier draws a current from one of the feedback elements to exactly match the amount of current the ion chamber is contributing. If a higher ion chamber current occurs, the amplifier must produce a higher voltage across the feedback element to draw off the current. In this way, the amplifier voltage output is proportional to the chamber current which is, in turn, proportional to the rate of radiation at the chamber.

3. METER CIRCUIT

The meter is driven directly from the output of the amplifier (Q12 collector) through dropping resistor R24 and one of nine calibrating resistors, R25 through R33. Nominally, the meter reaches full scale on all ranges at approximately the same voltage output from the amplifier. The nine calibrating resistors allow for manufacturing tolerances in various components and provide for calibration at various elevations and temperatures. Function switch, S1, section C determines which calibration resistor is in the circuit. Capacitor C11 sets the time constant for the meter circuit.

4. RANGE SWITCHING

The range that the Model RO-1 is operating on depends entirely on the feedback circuitry between the output of the amplifier and the amplifier input, pin 3 of Q7, which is connected to the ion chamber. Table 3-1 shows the nominal current and voltage conditions of the circuit when at full scale on the nine ranges (sea level, 0°C).

The feedback elements are connected to the ion chamber by glass encapsulated reed switches S3, S4 and S5. They are activated by coils L1, L2 and L3. The rear contacts of the first section of switch S1 (S1-AR) control which element will be connected according to the range selected.

The second section of S1 (S1-B) selects full amplifier output voltage or one-tenth or one-hundredth of that voltage to supply the feedback elements according to whether a 500, 50 or 5 position of the range switch has been chosen.

Reed switch S6 is the "zero" feedback connection. When it is closed, the feedback element in use is shorted out by S6 so that feedback current can not generate any voltage drop across the element. When this occurs, any voltage remaining on the amplifier output and showing on the meter is zero offset error. This offset can be removed with the ZERO SET control, R15, which re-balances the amplifier with both gates of Q7 at zero potential. For maximum accuracy, this adjustment should be made only on a "5" position of the range switch.

S6 is normally held closed by a permanent magnet mounted near it. This is done to prevent stressing the gate insulation of Q7 when the Model RO-1 is turned off and the +100 volt potential in the chamber bleeds off. In normal operation, coil L4 is powered and opposes the field of the permanent magnet, allowing S6 to remain open. When the ZERO pushbutton is depressed, power is removed from L4 and the permanent magnet closes S6. Power is prevented from reaching L4 when the function switch is at the BATT position so that during turn on, S6 is closed to protect the gates as the chamber voltage rises.

RANGE SETTING	ION CHAMBER CURRENT, AMPS FULL SCALE	FEEDBACK ELEMENT	VOLTAGE ON FEEDBACK ELEMENT	VOLTAGE OUT OF AMPLIFIER Q12 COLLECTOR
5 mR/hr	1.16×10^{-13}	R10, 5×10^{11} ohm	0.058	5.8
50 mR/hr	1.16×10^{-12}	R10, 5×10^{11} ohm	0.58	5.8
500 mR/hr	1.16×10^{-11}	R10, 5×10^{11} ohm	5.8	5.8
5 R/hr	1.16×10^{-10}	R9, 5×10^{8} ohm	0.058	5.8
~~50 R/hr~~	1.16×10^{-9}	R9, 5×10^{8} ohm	0.58	5.8
~~500 R~~/hr	1.16×10^{-8}	R9, 5×10^{8} ohm	5.8	5.8
~~RANGE SETTING~~	~~INTEGRATED CHARGE, COULOMBS FULL SCALE~~	~~FEEDBACK ELEMENT~~	~~VOLTAGE ON FEEDBACK ELEMENT~~	~~VOLTAGE OUT OF AMPLIFIER Q12 COLLECTOR~~
~~5 mR~~	~~4.18×10^{-10}~~	~~C9, 7500 pf~~	~~0.056~~	~~5.6~~
~~50 mR~~	~~4.18×10^{-9}~~	~~C9, 7500 pf~~	~~0.56~~	~~5.6~~
~~500 mR~~	~~4.18×10^{-8}~~	~~C9, 7500 pf~~	~~5.6~~	~~5.6~~

Table 3-1. Full Scale Currents and Voltages

RO3 5R/h MAX
doesn't integrate

5. POWER SUPPLY

The power supply circuit, mounted on the plug-in printed circuit board, generates plus and minus 10 volts to operate the amplifier and +100 volts to supply the ion chamber. Components Q1, Q2, R1, R2, C1, C2 and the primary of T1 form an oscillator. The secondary of T1 is tapped at certain places to provide the necessary voltages. The voltage at pin 4 of T1 is half-wave rectified to supply the +100 volt circuit. The voltages at pins 5 and 6 are half-wave rectified to supply the ±10 volts circuits. Transistors Q3 and Q4 in the plus 10 volt circuit and Q5 and Q6 in the minus 10 volt circuit form current limiters to conserve battery life. All three voltage outputs are zener regulated.

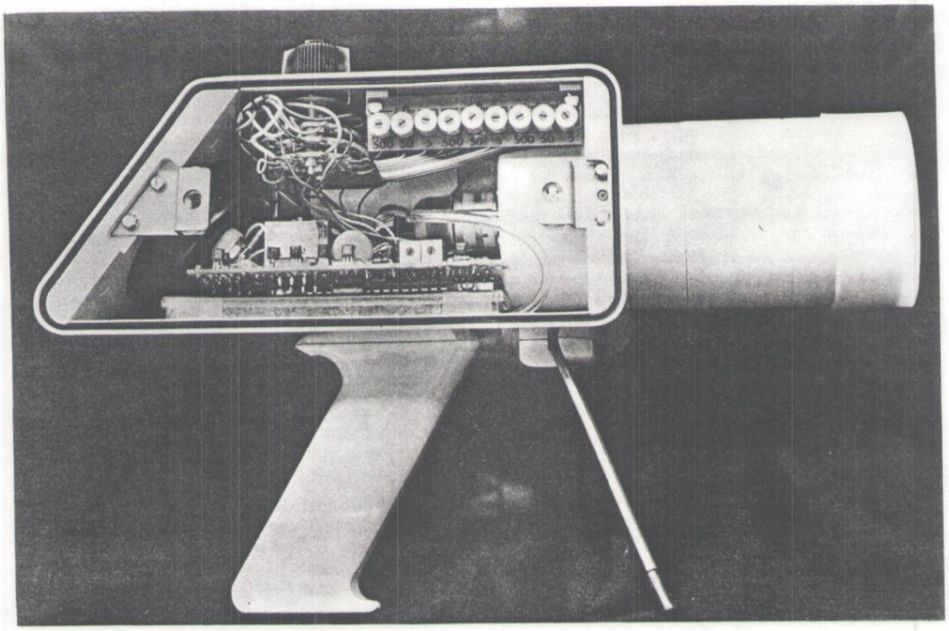


Figure 4-1. RAD OWL, Interior View

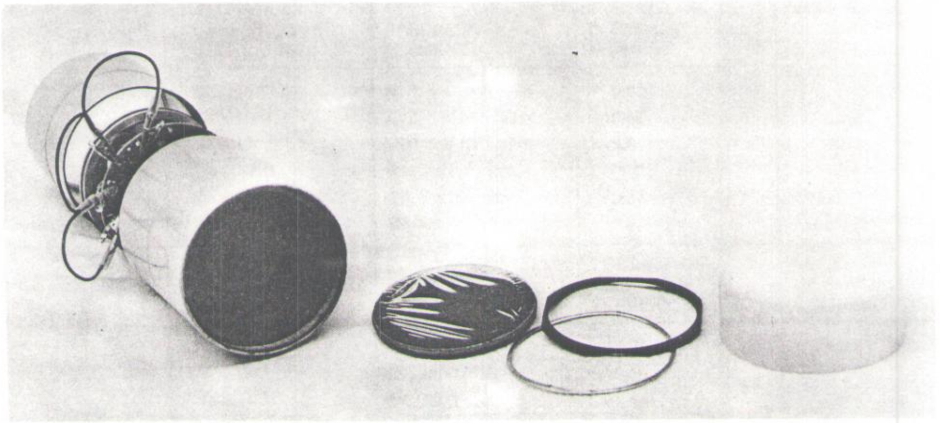


Figure 4-2. Chamber Disassembly

SECTION IV
MAINTENANCE

A. PREVENTIVE MAINTENANCE

1. Replace the batteries when, during BATT check, the meter indicates at or below the left end of the BATT OK line on the meter face. The batteries are accessible when the left side panel is removed. Use a small screwdriver to remove the holder clips.

2. Remove the batteries if the instrument is to be inactive for a long period.

3. Dry or replace the desiccant crystals when they first begin to turn clear or pink in color. To remove the desiccant box, remove the right side panel, remove the plug-in circuit board and slip the plastic hose off of the pipe at the back of the chamber assembly. The box can then be removed by sliding it outward from under the clamp. When new or dried crystals are in place in the box, retape the lid to the box (lengthwise) and reinstall. Do not seal the box completely with tape. Leave a small space so that air can enter and leave the box. The desiccant crystals can be repeatedly dried by heating to 250°F for 12 hours or to 400°F for one hour. Do not heat the plastic box. The desiccant life will be prolonged if the box is placed in a small plastic bag with a rubber band closing the bag around the plastic hose.

NOTE

It is very important that the inside of the chamber assembly be kept dry to avoid leakage currents due to moisture. If the desiccant becomes saturated and the RO-1 becomes erratic due to moisture, open the chamber face slightly and flush the assembly thoroughly with dry air or dry nitrogen. Seal with dry air or nitrogen inside. See paragraphs C9, C11. An alternate method is to renew the desiccant crystals and cycle the instrument between room temperature (or lower) and +140°F three or four times to flush the chamber air across the desiccant.

B. CALIBRATION

For maximum accuracy, the RO-1 should be calibrated at approximately the same temperature and air pressure as is expected for its use. If the conditions for calibration and for use are necessarily different, an offset may be used during calibration so that the instrument will read properly when put in use. Tables 2-1 and 2-2, Section II may be used to select the proper offset in this case.

To calibrate the dose rate ranges, remove the right side cover and position the RO-1 so that the ion chamber is in a gamma field of known intensity. Adjust the calibration control (corresponding to the range switch position) for the proper meter indication. For best accuracy, choose a calibration field strength that will cause the meter to read around the 4 mark when calibrated. Repeat the procedure for all 6 rate ranges.

To calibrate the three integrating ranges, place the chamber in a gamma field which will produce a total dose of around 4 on the meter in a reasonable period of time, such as one minute, for example. To start the integration period, depress the ZERO pushbutton while the RO-1 is in the gamma field or zero the meter and then rapidly place the RO-1 in the field at the start of the timing period. At the end of the time, rapidly remove the instrument from the field and then adjust the appropriate calibration control for the proper reading on the meter. Repeat for all three ranges.

To avoid errors, the entire ion chamber of the RO-1 must be in the gamma field when calibrating. The effective center of the chamber is marked by a groove around the outside about 1-3/4" from the front end.

WARNING

The gamma field intensities required for the complete calibration of the RO-1 are potentially hazardous to personnel. Observe proper precautions to prevent injury.

C. DISASSEMBLY AND REASSEMBLY

1. Side panels may be removed by rotating the two latches one-quarter turn to the left and lifting panel out.

2. The batteries may be removed by prying the retaining clip off with a small screwdriver.

3. The plug-in printed circuit board may be removed by pulling it out of the socket.

4. To remove the desiccant box, slip the plastic tube off of the pipe at the rear of the chamber assembly and slide the box outward from under the retaining clip.

5. To remove the meter, remove the three retaining screws from the meter bezel, pull the meter out part way and then remove the wires from the terminals.

6. To remove the chamber assembly, loosen the two set screws (one on each side), and slide the assembly out forward. Disconnect the plug by rotating the outer ring one-quarter turn to the left.

7. To expose the detector assembly electronics section, grasp the forward half of the assembly and unscrew the rear cylindrical cover.

CAUTION

The dual MOSFET transistor, Q7, is highly susceptible to damage from static charges. When this cover is removed, Q7 should immediately be protected by clipping pins 5, 7, 1 and 3 together in that order. Touch a grounded area (black surface at chamber rear, metal standoff, etc.) with finger prior to clipping Q7 leads. Soldering irons must be clipped to ground point prior to touching any part of this assembly.

8. To remove the round circuit board from the detector assembly, remove the two screws holding the back plate. Unscrew the two hexagonal standoffs, unsolder the three wires to the chamber and lift off the board.

9. To remove the chamber face, remove the end cap and pry out the outer snap ring with a small screwdriver. Lift out the spring washer and then, with a small knife blade, pry out the face assembly. (It is held in by O-ring pressure.)

NOTE

The face may be removed while the rest of the instrument is completely assembled. Be sure the function switch is in the OFF position to protect Q7, the MOSFET.

10. With the chamber face removed, the chamber center electrode may be unscrewed and removed.

11. For reassembly, reverse the procedure used in disassembly. The chamber assembly should be kept as clean as possible and when closing it, flush with dry air or dry nitrogen to remove moisture. The use of commercial aerosol "dry air" cans is not advisable since the gas is normally not air and a shift in calibration may result. When installing the chamber face assembly, make sure the vent grooves cut in the nylon support ring are toward the outside, away from the chamber.

D. DESIGN DATA

1. The plus and minus 10 volt power supplies use current limiters Q3, Q4 and Q5, Q6. They operate by maintaining a base to emitter voltage drop across R5 and R6. At a nominal 0.6 volt drop, the current will be limited to 1.07 milliamps in each supply.

2. The constant current circuit supplying Q7 is made up of Q8 and R16. R16 is adjusted for a nominal current of 350 microamps which produces 3.5 volts across R13 and R14.

3. The constant current circuit supplying Q10 and Q11 is made up of Q9 and R17. R17 is adjusted so that the voltage across R18 is the same as across R19 which is the base to emitter drop across Q12. Nominal current is 260 microamps through Q9.

4. The current through Q12 varies from 25 to 125 microamps, depending on the output of the amplifier at Q12 collector.

5. The current taken from the ±10 volt supplies is 735 microamps nominal which leaves 335 microamps going through zeners CR5 and CR6.

6. The nominal resistance of coils L1-L4 is 250 ohms, making the current drain 12 milliamps at 3 volts and 8 milliamps at 2 volts.

7. Reed switch S6 is held closed by a permanent magnet located under L4. S6 opens when coil current through L4 counteracts the field of the magnet. A short piece of iron wire is placed alongside of the magnet to weaken its influence so that L4 can cause S6 to open. The position of the wire is adjusted so that S6 opens when the voltage on L4 reaches about 1.4 volts. A small piece of magnetic foil is placed between L1 and L4 to prevent the permanent magnet from influencing L1.

8. When the function switch is at the BATT position, the current load on the batteries is the same as when on any operating range. All circuits are completely active, but S6 is pulled in and the meter is connected to the batteries instead of the amplifier.

9. The silica-gel in the desiccant box may be rejuvenated by heating the gel (not the plastic box) to 250°F for 12 hours or to 400°F for one hour.

E. TROUBLESHOOTING

The schematic diagram Figure 6-1, the system block diagram Figure 3-1, and Section III, Theory of Operation, are the primary aids to troubleshooting.

1. BATTERY LIFE

If battery life is excessively short, the most probable cause is a failure in the limiter circuits in the ±10 volt power supplies. Excessive loading or a failure in the amplifier or +100 volt line will cause no significant increase in battery drain due to the limiting action. The battery drain will not typically exceed 44 milliamps at 2 volts or 58 milliamps at 3 volts.

2. AMPLIFIER

The amplifier has a nominal voltage gain of 5000 between Q7 pin 3 and Q12 collector. In normal operation, the voltages across R13 and R14 are equal at about 3.5 volts. The base to emitter voltages on Q10 and Q11 are equal at about 0.5 to 0.7 volt. The voltage across R19 is 0.5 to 0.7 volt. The voltage across R18 depends on the adjustment of R17. It should be set so that the voltage on R18 equals that on R19. The sources of Q7, pins 1 and 7 typically run between 2 and 5 volts positive with respect to ground and within 100 millivolts of each other.

If the meter remains pegged and will not zero when the ZERO pushbutton is pressed, check for proper power supply voltages and check the voltages at the points discussed in the preceeding paragraph. Try grounding pin 3 of Q7 by shorting the wiper of S1-B to ground while holding the ZERO pushbutton depressed and then see if the ZERO SET knob will affect the meter reading. If the meter remains pegged, work back from Q12 checking voltages on all three terminals of Q12, Q11 and Q10 to try to find an inconsistency indicating a failed component. If symptoms indicate Q7 has failed, it is advisable to protect it with shorting clips while removing it in case it turns out to be okay. See NOTE in paragraph C7 above. The leads of Q7 have been left long so that it can be clipped out one lead at a time to protect the printed circuit board and still be re-installed, if found to be okay. When installing a new unit for Q7, take every precaution (shorting clips, grounded soldering iron, etc.) to prevent damage.

3. HIGH IMPEDANCE COMPONENTS

Several components connect to the point in the circuit where the extremely minute ion chamber current flows. It is of the utmost importance that they be clean, free of fingerprints and carefully installed. They include the gate of Q7 (pin 3), the three feedback components R9, R10 and C9 and all four reed switches S3 to S6. The leads of these components are not supported on insulators or mounted on the printed circuit board. They are air insulated wherever possible. The leads between the reed switches and feedback components pass through quarter-inch clearance holes and they should be nearly centered in the holes so as to not touch the board. All wiring in the chamber assembly, including the two wires to the capacitor on the back of the chamber proper, should be dressed away from the high impedance components.

If leakage currents appear to be a problem, make sure the silica-gel in the desiccant box is dark blue. Flushing both the chamber and the electronic section of the chamber assembly with dry nitrogen or dry air is advisable. Heating the opened assembly (face removed) for several hours at 160°F to drive off volatiles may help. The use of a high purity, mild, "Freon" solvent spray to clean the high impedance components may help. Do not use an alcohol spray since it will dissolve the dag coating used in the assembly.

4. CHAMBER FACE ASSEMBLY

The inside mylar face is at +100 volt potential and the outer face is at ground potential to provide electrostatic shielding. The inside and outside faces must necessarily be kept separated. If the RO-1 becomes sensitive to movement in its vicinity, the outer face probably has lost its ground connection through the outside dag coating, the dag-covered snap ring and the spring washer. Repainting the various areas with conductive dag coating should correct the problem.

SECTION V
PARTS LIST

The following tables list the electronic items incoporated in the RO-1 and should contain any part necessary for normal electronic repair. Unless otherwise specified, callouts of manufacturers and manufacturer's part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number (RO-1), serial number, reference designation and value, or a word description if the part has no reference designation. Examples: R13, 20K resistor, RO-1, S/N 115; or Battery Holder, RO-1, S/N 115, etc. Eberline will automatically substitute equivalent parts when the one called out by manufacturer's part number is not available.

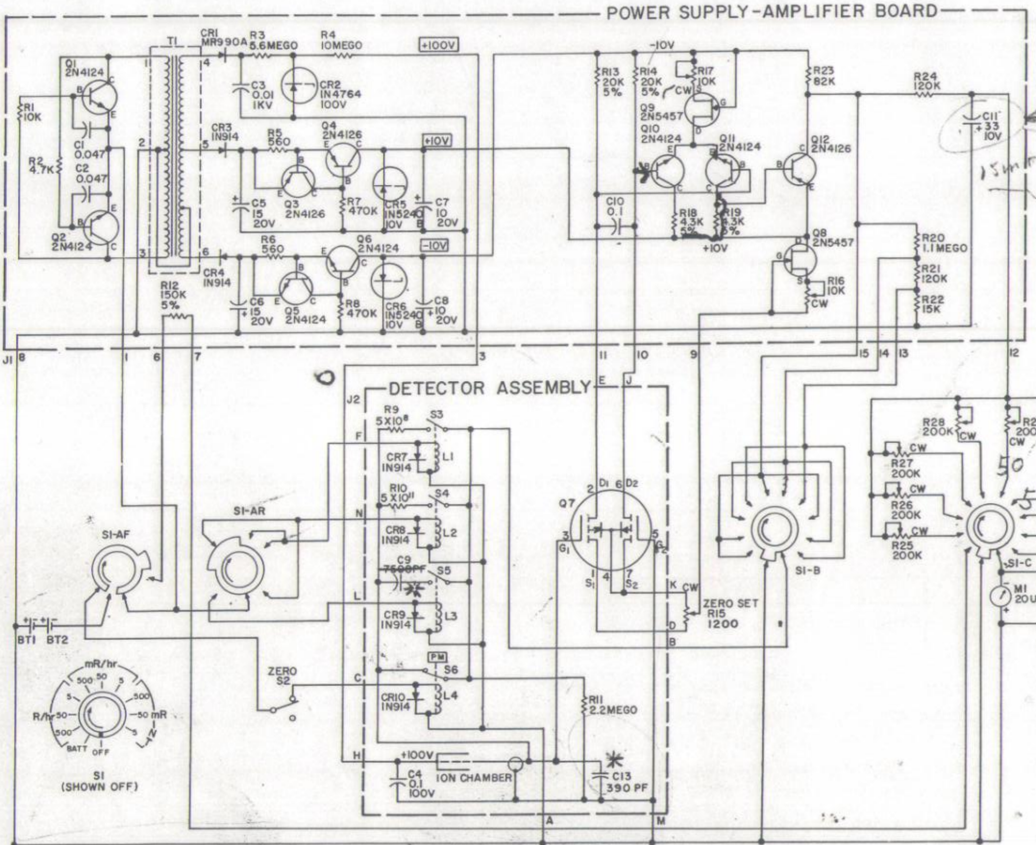
221903

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
BT1, BT2	Battery		D Cell, Eveready 1050 or equiv.
C1, C2	Capacitor	.047 mfd, 20%, 200V	Sprague 192P47392
C3	Capacitor	.01 mfd, 20%, 1KV	Sprague 5GA-S10
C4	Capacitor	.1 mfd, 10%, 400V	CDE WMF-4P1
C5, C6	Capacitor	15 mfd, 20%, 20V	Kemet K15C20
C7, C8	Capacitor	10 mfd, 20%, 20V	Kemet K10C20
C9	Capacitor	7500 pf, 5%, 500V	Mallory Type SX or CRL CPR7500J
C10	Capacitor	.1 mfd, 10%, 100V	Sprague 225P-10491
C11	Capacitor	33 mfd, 20%, 10V	Kemet K33C10
C12	Capacitor	15 mfd, 20%, 10V	Kemet K15C10
C13	Capacitor	390 pf, 20%, 600V	CRL CPR390J
CR1	Rectifier	1 KV PIV	Motorola MR990A, 1N4006 or 1N4007
CR2	Diode, Zener	10%, 100V	Motorola 1N4764
CR3, CR4, CR7, CR8, CR9, CR10	Diode		1N914
CR5, CR6	Diode, Zener	10V, 5%	1N5240B
J1	Receptacle		Viking 2VK15S/1-2
J2	Receptacle		Amphenol 165-11
L1, L2, L3, L4	Coil		James Electronics 7801
M1	Meter	20 ua	EIC 10567-B87 321HR (0-20)
P2	Plug		Amphenol 165-10-1000
Q1, Q2, Q5, Q6, Q10, Q11	Transistor		2N4124
Q3, Q4, Q12	Transistor		2N4126
Q7	Transistor	Dual MOSFET	GI MEM 551C
Q8, Q9	Transistor	JFET	2N5457

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
R1	Resistor	10K, 10%, 1/4W	
R2	Resistor	4.7K, 10%, 1/4W	
R3	Resistor	5.6M, 10%, 1/4W	
R4	Resistor	10M, 10%, 1/4W	
R5, R6	Resistor	560, 10%, 1/4W	
R7, R8	Resistor	470K, 10%, 1/4W	
R9	Resistor	5×10^{8}, 10%	Victoreen RX-1 H1-MEG
R10	Resistor	5×10^{11}, 10%	Victoreen RX-1 H1-MEG
R11	Resistor	2.2M, 10%, 1/4W	
R12	Resistor	150K, 5%, 1/4W	
R13, R14	Resistor	20K, 5%, 1/4W	
R15	Potentiometer	1200, 20%, Linear	CTS EF5927
R16, R17	Potentiometer	10K, 20%, 1/2W	Spectrol 53-2-1-103
R18, R19	Resistor	4.3K, 5%, 1/4W	
R20	Resistor	1.1M, 10%, 1/4W	
R21, R24	Resistor	120K, 10%, 1/4W	
R22	Resistor	15K, 10%, 1/4W	
R23	Resistor	82K, 10%, 1/4W	
R25-R33	Potentiometer	200K, 20%, 1/2W	Spectrol 53-1-1-204
S1	Rotary Switch		EIC 10567-B26
S2	Switch		Microswitch 1PB5
S3-S6	Reed Switch		Hamlin MRR-2-17.5-22.5
T1	Transformer		Microtran M6772
		Chamber Face Assy	EIC 10567-B24
		Desiccant, Indicating Silica Gel	No. 6-16B Eagle Chemical Co. P. O. Box 107 Mobile, Alabama
		Conductive Coating Dag Dispersion	No. 154 Acheson Colloids Co. Port Huron, Michigan 48060

SECTION VI

DIAGRAMS



* To change Response From 8 sec to 2 sec

15 mfd

NOTES:
1. ALL CAPACITOR VALUES IN MICROFARADS EXCEPT AS NOTED.
2. ALL RESISTOR VALUES IN OHMS. K=10³ MEGO=10⁶
ALL RESISTORS 10% EXCEPT AS NOTED.

Figure 6-1. General Schematic of Model RO-1

* Selected
At manufacture
C9 = 7500 For 500, 50, 5

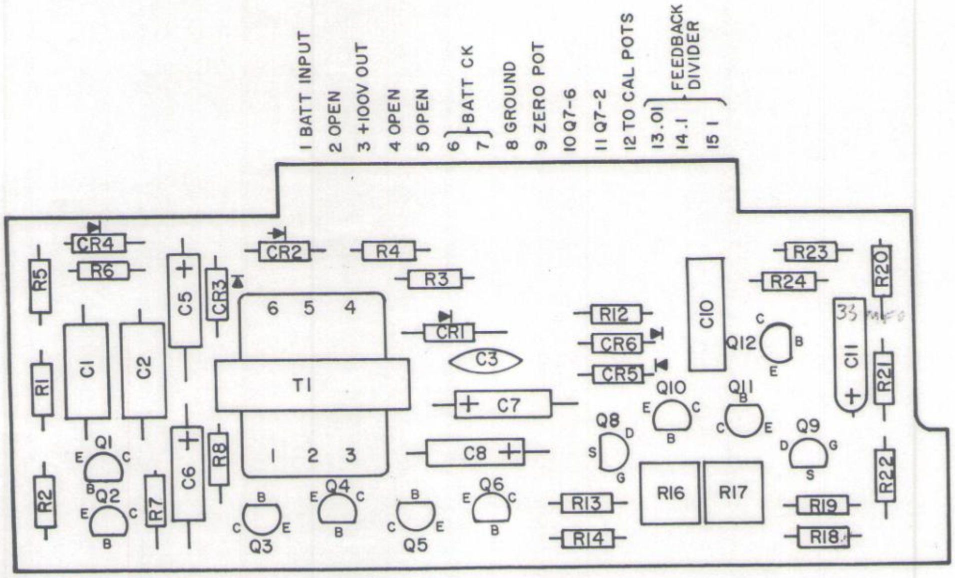


Figure 6-2. Component Layout of Plug-in Board

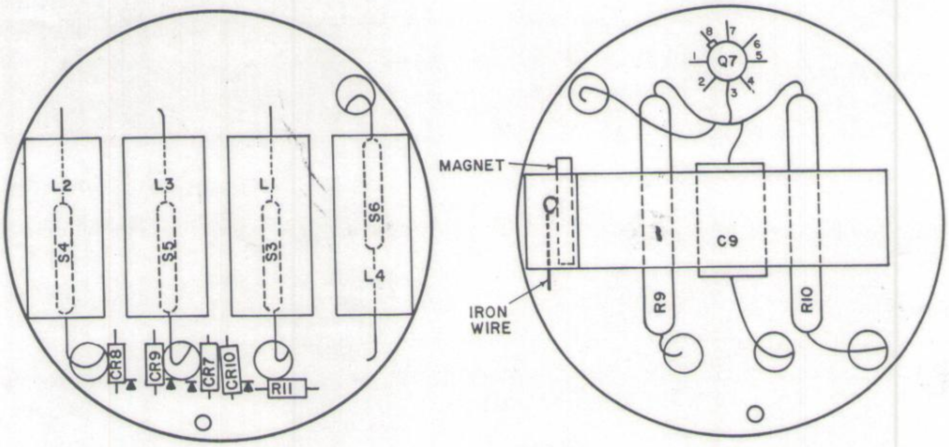


Figure 6-3. Component Layout of Detector Assembly Board